(12) **UK Patent Application** (19) **GB** (11) **2 183 817** (13) **A**

(43) Application published 10 Jun 1987

(21) Application No 8626970

(22) Date of filing 12 Nov 1986

(30) Priority data
(31) 8527874 (32) 12 Nov 1985 (33) GB

(71) Applicant
Robert Dominic Walker,
Trecwn, Nauadd Cross, Ponthirwaun, Cardigan, Dyfed

(72) Inventor
Robert Dominic Walker

(74) Agent and/or Address for Service
Baron & Warren,
18 South End, Kensington, London W8 5BU

(51) INT CL[4]
F24J 2/24

(52) Domestic classification (Edition I):
F4U 60

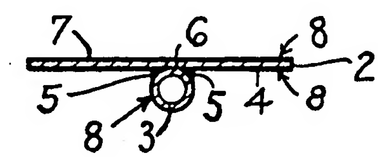
(56) Documents cited
GB A 2010466 GB 1555470

(58) Field of search
F4U
Selected US specifications from IPC sub-class F24J

(54) Heat exchange elements

(57) A heat exchange element and a method of making the same in which a length of micro-bore metal tubing (3) is bonded to a thin metal absorber plate (2) of 24 to 30 gauge by a bonding mastic (5) which in the cured state retains its flexibility and has good heat transfer and adhesive properties. The surfaces (4 and 7) of the plate (2), the tubing (3), and the exposed surface of the cured mastic (5) are provided with a heat absorptive coating (8) of matt black paint.

Fig.2



GB 2 183 817 A

12 NOV.86- 26970
DFA

2183817

1/2

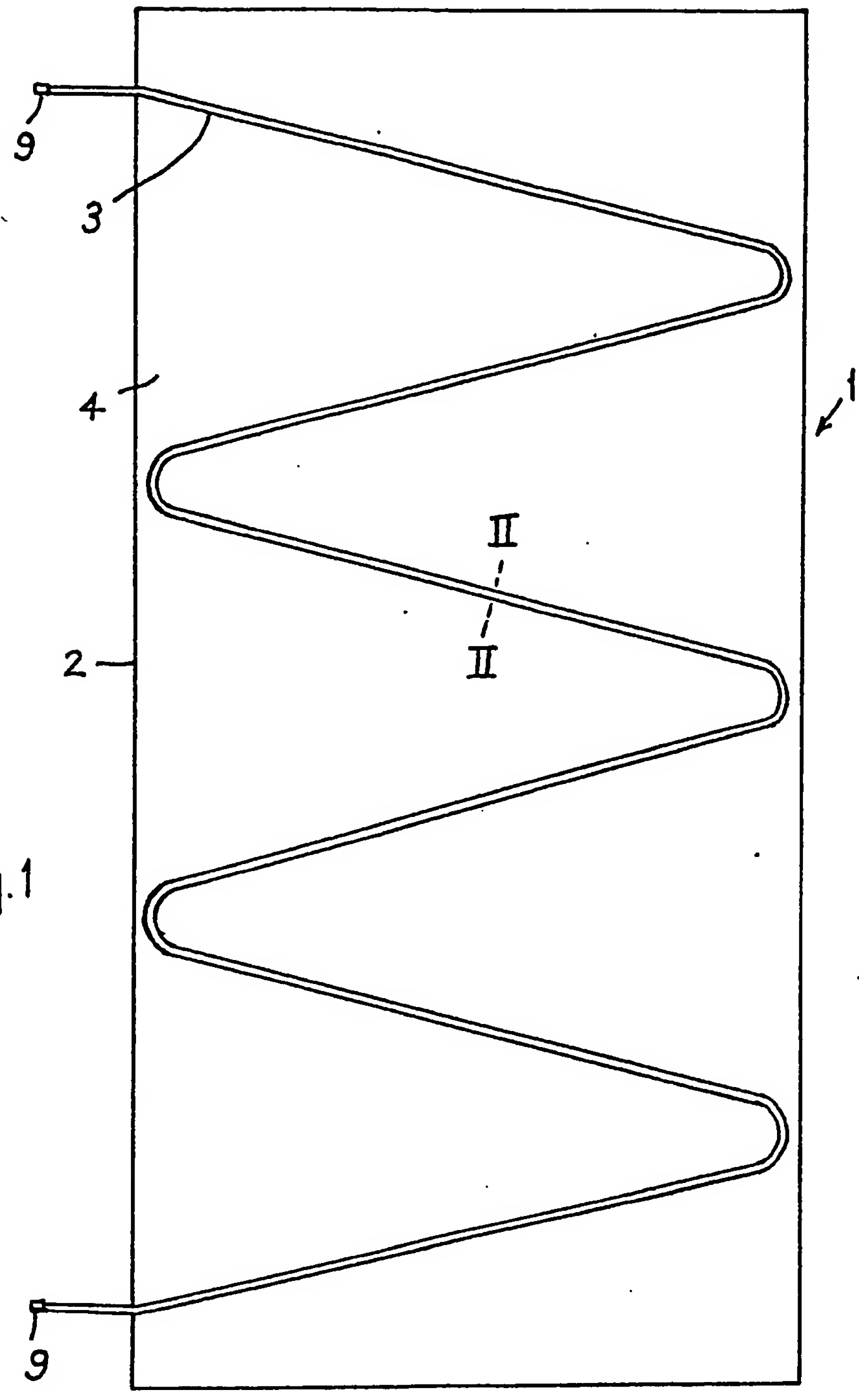
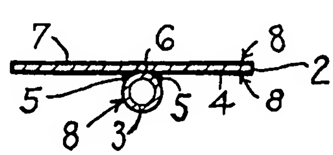


Fig.1

Fig.2



12 NOV.86- 26970
DFA

2183817

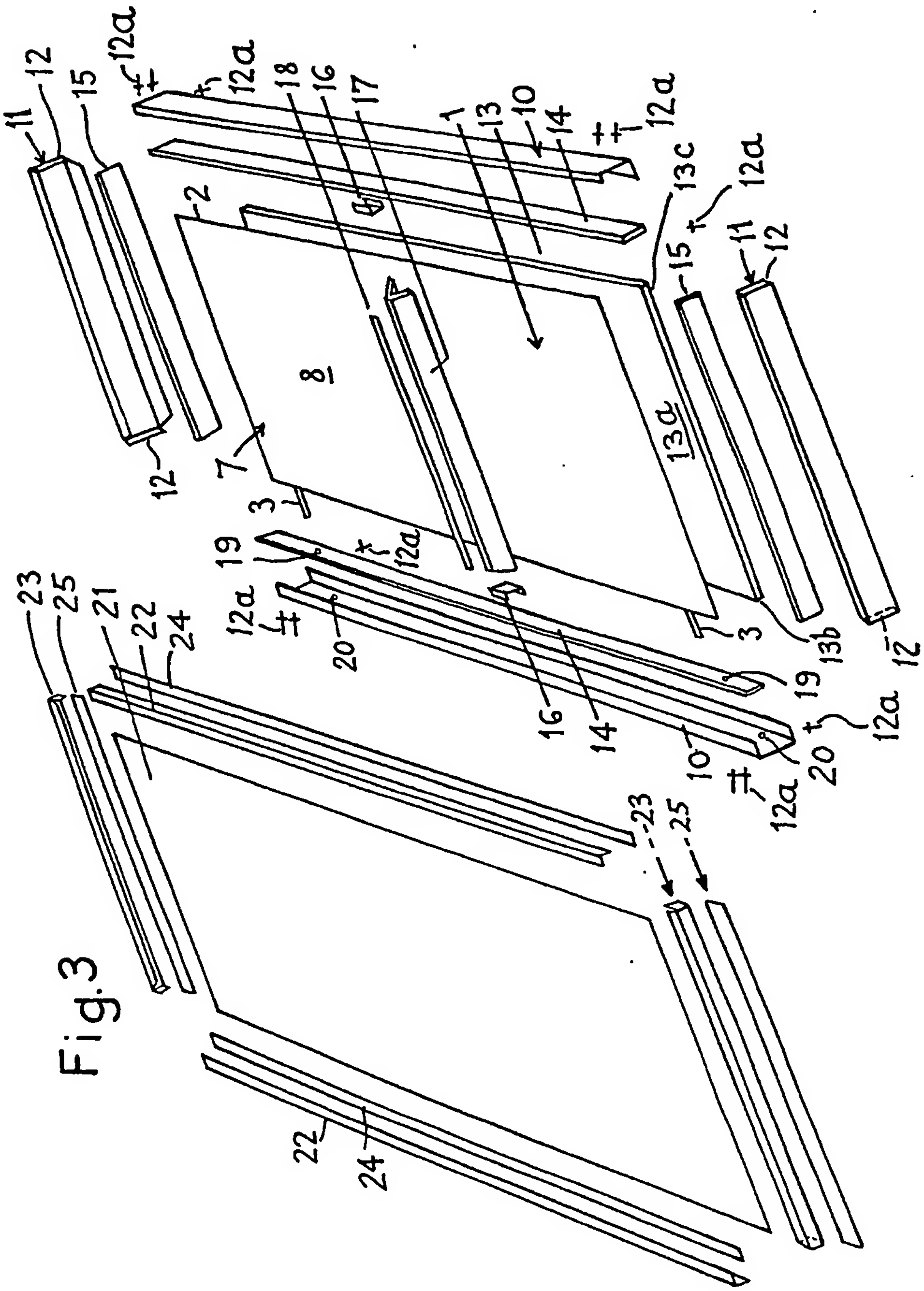


Fig.3

SPECIFICATION

Heat exchange elements

This invention relates to heat exchange elements and, more particularly but not exclusively, to heat exchange elements suitable for use as part of a solar panel.

There are many forms of solar panels available on the market nowadays which generally consist of a heat exchange element housed in an insulated container having an open top which is closed by a transparent panel. One form of heat exchange element in common use comprises a metal absorber plate, e.g. of steel, to which is welded a length of metal tubing, e.g. of copper, arranged in a series of loops. Water passed through the tubing from one end to the other is heated during its passage by exposure of the absorber plate to sunlight through the transparent panel. In order to prevent internal frictional losses with consequential reduction in the rate of water flow through the tubing leading to a significant drop in efficiency, it has been always considered necessary for the tubing to have a sufficiently large internal diameter and one which has gained wide acceptance is an internal diameter of 0.5 inch (12.70 mm), with the tubing having an external diameter of 0.579 inch (14.70 mm).

It has also always been considered necessary under normal fabrication procedures for the absorber plate to be of heavy gauge, typically 3/16 gauge to collect solar energy. This is not just because of conventional thinking but also because in practice it is not possible to weld the length of tubing to a thin sheet of plate without distortion. Moreover, in order to obtain effective heat conduction into the tubing and the water content it is also necessary to weld along the full length and along each side of the tubing.

Thus such heat exchange elements have the disadvantage of being expensive to manufacture, thereby militating against wide usage of solar heating in particular for domestic purposes as the initial total cost of solar panels incorporating these heat exchange elements and installation is not justifiable with respect to the time taken to recover the cost from fuel savings. A further disadvantage results from the thickness of the heavy gauge absorber plate, causing the rate of heat absorption into the water flowing through the tubing to be slow with the water working some time after the solar energy has been received by the absorber plate. Furthermore, because of the large internal diameter of the tubing the tubing metal content to water ratio is undesirably low despite the 2mm wall thickness of the tubing.

Accordingly, the main object of this invention is to provide a heat exchange element and a method of making a heat exchange element in which the aforesaid disadvantages are reduced or eliminated.

To this end, and from one aspect, the invention consists in a heat exchange element comprising a thin metal absorber plate, for example having a gauge in the range of 24 to 30, a length of metal tubing which is bonded to one surface of the absorber plate in at least one loop by means of a bonding material which is preferably applied in the form of a mastic, which has similar or substantially the same heat transfer properties as a metal, e.g. steel or copper and which retains flexibility, said tubing being of micro-bore size, for example having an internal diameter of 6 mm, and a heat absorptive coating covering at least the two oppositely facing surfaces of the absorber plate and preferably the tubing and bonding material.

Applicants have found that the heat absorptive coated absorber plate, bonding material, and microbore tubing has surprising, and unexpected effects and advantages. Even in winter conditions with dispersed sunlight filtering through clouds and hitting the thin absorber plate heat travels rapidly through the plate, the bonding material and into the metal of the tubing. As the water in the tubing heats up it starts to flow upward thermally and thence draws a very high proportion of the absorbed heat into the flowing water. If the absorber plate were a thicker sheet, the water would be working some time after the solar energy was received but by utilizing a very thin sheet of metal the water is nearly working on the instant the energy is received. Moreover, the micro-bore size tubing has normally the disadvantage of causing internal friction, but in the present invention the small internal diameter of the tubing enables the water content of 0.025 pints per total, 4 metre run, i.e. 0.0021 gallons per foot run, to be directly effected by a heated metal content of nearly 1-1/2 ounces and so has the advantage that it heats the small water content very quickly. Preferably, the ratio of tubing metal content to heated water quantity is 9.7 lbs of metal heating 0.25 pints of water. In tests carried out by the Applicant with heat exchange elements constructed in accordance with the invention, 5.5 gallons of water per hour were heated to near boiling point.

Preferably the bonding material is a thermosetting resin having a thermal conductivity of at least 0.3 w/m °C or at least 0.15 Btu ft/ft²h °F, preferably an epoxy resin cured with an amine curing agent having a thermal conductivity of 0.35 w/m°C.

By utilizing the solar energy through a thin sheet covered by a heat absorptive coating fast heat is immediately obtained which is transferred quickly into a small water content which heats up veryfast and therefore starts a faster flow and syphoning action than conventional systems under both summer and winter

conditions. In winter conditions heat exchange elements constructed in accordance with the invention are more effective than conventional units by reason of the coated absorber plate, coated tubing metal and water content balance and relationship.. Very little solar energy will start a thermal flow.

A substantial further advantage is accrued in that by using light weight material and micro-bore tubing a very cost effective solar collector can be produced.

Preferably, the tubing has an external diameter of 0.315 inch (8 mm) and an internal diameter of 0.1964 inch (6 mm) providing a wall thickness of 0.0394 inch (1 mm) which has been found to provide an optimum tubing metal water content ratio, a ratio which is far higher than that provided by conventional 0.5 inch internal diameter tubing.

Steel is preferred for reasons of cost for the material of the absorber plate and the steel may be galvanized e.g. hot dipped matt or roughened and etched spangled. In view of its good heat conductive properties copper is the preferred material for the tubing.

The heat absorptive coating is conveniently a suitable paint such as a black paint or green paint which is heat resistant up to at least 160°C and may be applied by immersing the panel comprising the absorber plate, bonding material and tubing in a bath of the paint such that the coating has a thickness in the range of 0.25 mm to 0.5 mm for example. The preferred coating is matt black.

In a preferred embodiment of the invention, the tubing is in contact with the surface of the absorber plate and the bonding material is applied on opposite sides of the contact line of the tubing with the plate which provides for very good heat transfer from the plate to the tubing. The thermal conductivity of the bonding material may be 0.228 B Th U per °F. The bonding material may have heat transfer characteristics which are almost or substantially equivalent to those of a metal, e.g. the steel absorber plate and/or copper tubing which considerably increases heat transfer from the absorber plate to the tubing.

The invention also consists in a solar collector or panel including any of the heat exchange elements defined hereinabove. The heat exchange element is conveniently disposed in an open topped container with the tubing facing the container bottom and with the open top of the container being closed by a transparent panel.

The container may be provided with an insulating backing member along its bottom or the insulating backing member may form the bottom of the container with the tubing facing or preferably being in contact with the insulating backing member. The container is advantageously also provided with insulating material along its sides or the sides may be formed of insulating material.

In a preferred embodiment, the solar collector comprises a reflective insulating backing member comprising a reflective layer which faces or is preferably in contact with the tubing, and an insulating layer. When such a backing member is mounted in or forms the bottom of, the container the efficiency of the solar collector is increased by as much as 10%. The reflective layer may be of a suitable metal such as aluminium or stainless steel, say in the form of a sheet of a thickness in the range of 1 mm to 2 mm. whereas the insulating layer may be a suitable plastics, such as polyisocyanate for example in the form of a foam. The insulating layer should be able to withstand, i.e. remain stable, at temperatures of at least 150°C. The thickness of the insulating layer is conveniently in the range of 0.5 to 1 inch. The whole backing member is advantageously self-supporting and of a rigidity such as to maintain its shape and thus remain at the same spacing from or in contact with the tubing without distortion. Thus, it may be necessary for the backing member to have a reflective layer on its other surface, which is of the same dimensions as the reflective layer facing or in contact with the tubing. The multi-layered backing member may be formed in an injection moulding process.

From another aspect the present invention consists in a method of making a heat exchange element, said method comprising providing a thin metal absorber plate and a length of micro-bore metal tubing, forming the metal tubing into at least one loop, clamping the looped tubing in line contact with one surface of the absorber plate along the length of the tubing, applying a bonding material in the form of a mastic along at least one of the two sides of said line of contact the tubing with the absorber plate, allowing the bonding material to cure to bond the tubing to said surface of the absorber plate and applying a coating of a heat absorptive material to, and such as to cover at least the two oppositely facing surfaces of the absorber plate and preferably the tubing and cured bonding material.

The bonding material retains its flexibility and has good heat transfer and adhesive properties in the cured state. With one form of bonding mastic used by the Applicants, curing periods of 24 hours at a temperature of 24°C, 2 hours at 66°C, 5 minutes at 12°C and 2 minutes at 177°C have been used.

The combination of the heat absorptive coating on the undersurface of the absorber plate with the reflective property of the insulating backing member means that the absorber plate will collect reflected heat and thus gain greater efficiency.

In order that the invention may be more readily understood, an embodiment thereof will now be described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is an underneath plan view of a heat exchange element constructed in accordance with the invention,

Fig. 2 is a cross-section taken along the line II-II of Fig. 1 to an enlarged scale and

Fig. 3 is an exploded view of a solar panel or collector incorporating the heat exchange element of Fig. 1.

Referring to Figs. 1 and 2, the heat exchange element is generally indicated at 1 and comprises a rectangular absorber plate 2, e.g. of 4 feet × 2 feet, consisting of a thin steel sheet 2 of 24 gauge or thicker having a looped length of micro-bore copper tubing 3 bonded to its undersurface 4 by an adhesive mastic 5. The bonding mastic 5 has good heat transfer properties (substantially the same or similar to those of a metal such as steel or copper) and adhesive properties and when cured, retains its flexibility. Preferably, as shown in Fig. 2, the tubing 3 is in line contact with the surface 4 of the plate 2 and the bonding mastic 5 is applied to the plate and tubing in the form of two strips whilst the tubing is clamped to the plate 2. The strips of bonding mastic are applied on opposite sides respectively of the line of contact, indicated at 6 such that heat transfer contact is made over substantially half the circumference of the tubing 4. When viewed in cross-section (see Fig.2) the contact line of the mastic with the plate may extend for a distance of up to around 12 mm. If desired, the tubing may be embedded in the bonding mastic up to substantially half its circumference, i.e. there is mastic between what would be the line of contact 6 and the metal plate 2. The surface 4 and other surface 7 of the plate 2, the tubing 3, and exposed surface of the cured mastic 5 are provided with a heat absorptive coating 8 of a suitable black matt paint to enhance the heat absorption properties, so that the panel shown in Fig. 2 is covered by the coating 8.

The copper tubing 3 has an internal diameter of 0. 236 inch (6mm) and an external diameter of 0.315 inch (8 mm) with the wall thickness of the tubing being 0. 079 inch (2mm). As can be seen from Fig. 1, the free ends of the looped tubing are extended beyond one side of the absorber plate 2 where they are joined to respective connectors 9 for connecting the tubing 3 to respective inflow and return pipes (not shown) for a heat exchange liquid such as water.

Referring now to Fig. 3, the heat exchange element 1 is mounted in an open-topped box formed of metal elongate side and end elements 10 and 11 respectively, preferably of galvanized steel. The elements 10 and 11 are of channel section with the end elements 11 being provided with end tabs 12 for use in securing the end and side elements together, for example with pop rivetts 12a passed through drilled holes in the side and end elements. The bottom of the box is constituted in this embodiment by a reflective insulating backing sheet 13 which is supported on the lower channel walls of the side and end elements 10 and 11 when the box is assembled. The backing sheet 13 comprises a reflective layer 13a, an insulating layer 13b and another reflective layer 13c. The box also includes side end strips 14 and 15 of insulating material which together with the base sheet 13 guard against any loss of heat from the copper tubing 3 to the exterior, the strips 14 and 15 being accommodated in the channels of their associated side and end elements 10 and 11.

Channel shaped side spacers 16 fit over the side strips 14 and an optional centre brace 17 is supported on the exposed surface 7 of the absorber plate 2 and is provided with a strip of insulating tape 18. The free ends of the tubing 3 pass to the exterior through apertures 19 and 20 in the left hand as illustrated side strip 14 and side element 10 when the box is assembled. Preferably, the strips 14 and 15 are provided with a covering of a reflective material such as aluminium foil (not shown) on their inwardly facing surfaces.

The open top of the box is closed by a transparent panel 21 of glass or a suitable plastics to be mounted in a frame comprising metal side and end elements 22 and 23 with side and end strips of insulating tape 24 and 25 being attached to the outer surface of the panel 21 where the elements 22 and 23 are to contact. The end elements 23 are also provided with end tabs for use in assembling the frame. When the frame is assembled with the transparent panel 21 therein it fits in the open top of the assembled box with the panel resting on the adhesive strip 18 attached to the brace 17. The copper tubing 3 is in contact with the reflective layer 13a of the backing sheet 13.

Various modifications may be made without departing from the scope of the invention. For example, instead of the plate 2 being of rectangular configuration it may be of any other suitable configuration. The heat exchange element described may be used with heat exchange mediums other than liquids for example a gaseous fluid.

Solar collectors constructed in accordance with the invention, to the best of the Applicant's knowledge, are simpler and much less expensive than any other constructions which have been produced in the past and which are known to the Applicant.

CLAIMS

1. A heat exchange element comprising a thin metal absorber plate, a length of metal tubing for a heat exchange medium, which is bonded to one surface of the absorber plate in at least one loop by means of a bonding material which is applied in the form of a

mastic, which retains some flexibility and which has good heat transfer properties, said tubing being of micro-bore size, and a heat absorptive coating covering at least the two oppositely facing surfaces of the absorber plate.

2. A heat exchange element as claimed in claim 1, wherein the heat absorptive coating also covers the tubing and the bonding material.

3. A heat exchange element as claimed in claim 1 or 2 wherein the heat transfer properties of the bonding material are similar to or substantially the same as those of a metal.

4. A heat exchange element as claimed in any one of claims 1 to 3, wherein the absorber plate has a gauge of 24 to 30.

5. A heat exchange element as claimed in any one of claims 1 to 4, wherein the tubing has an internal diameter of about 6 mm.

6. A heat exchange element as claimed in claim 5, wherein the tubing has a wall thickness of about 1 mm.

7. A heat exchange element as claimed in any one of claims 1 to 4, wherein a part of the circumference of the tubing is embedded in the bonding material along its length.

8. A heat exchange element as claimed in claim 7, wherein the tubing is in line contact with said one surface of the absorber plate and the bonding material extends on opposite sides respectively of the line of contact.

9. A heat exchange element as claimed in claim 7, wherein, a layer of the bonding material is interposed between the tubing and the absorber plate.

10. A heat exchange element as claimed in any one of claims 7 to 9, wherein the tubing is embedded in the bonding material up to substantially one half it's circumference.

11. A heat exchange element as claimed in any one of claims 1 to 10, wherein the ratio of tubing metal content to heated liquid heat exchange medium quanity is 9.7 lbs of metal heating 0.25 pints of liquid.

12. A heat exchange element as claimed in any one of claims 1 to 11, wherein the absorber plate is of steel and the tubing is of copper.

13. A heat exchange element substantially as hereinbefore described with reference to Figs. 1 and 2 of the accompanying drawings.

14. A solar collector incorporating a heat exchange element as claimed in any one of claims 1 to 13.

15. A solar collector as claimed in claim 14, wherein the heat exchange element is disposed in an open-topped container with the tubing facing the container bottom and with the open top of the container being closed by a transparent panel.

16. A solar collector as claimed in claim 15, wherein the container is provided internally with a reflective insulating layer at least along its sides.

17. A solar collector as claimed in claim 16, wherein the reflective insulating layer also extends along the container bottom and the tubing faces or is in contact with the reflective part of the insulating layer.

18. A solar collector as claimed in any one of claims 14 to 17, wherein the container is made from a number of lengths of material which are preferably rivetted together and the transparent panel is mounted in a frame which is supported on the container.

19. A solar collector substantially as hereinbefore described with reference to Figs. 1 to 3 of the accompanying drawings.

20. A method of making a heat exchange element, said method comprising providing a thin metal absorber plate and a length of micro-bore metal tubing, forming the metal tubing into at least one loop, clamping the looped tubing in line contact with one surface of the absorber plate along the length of the tubing, applying a bonding material of mastic along at least one of the two sides of said line of contact of the tubing with the absorber plate, and allowing the bonding material to cure to bond the tubing to said surface of the absorber plate, said bonding material retaining its flexibility and having good heat transfer properties in the cured state.

21. A method as claimed in claim 20, wherein the curing period for the bonding material mastic is about 36 hours at a temperature of about 24°C.

22. A method as claimed in claim 20 or 21, wherein the bonding material is applied along both sides of the line of contact such that the tubing is embedded in the adhesive mastic up to substantially one half of its circumference.

23. A method of making a heat exchange element, according to claim 20 and substantially as hereinbefore described.

24. A method of making a heat exchange element substantially as hereinbefore described with reference to Figs. 1 and 2 of the accompanying drawings.

Printed for Her Majesty's Stationery Office
by Burgess & Son (Abingdon) Ltd, Dd 8991685, 1987.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.